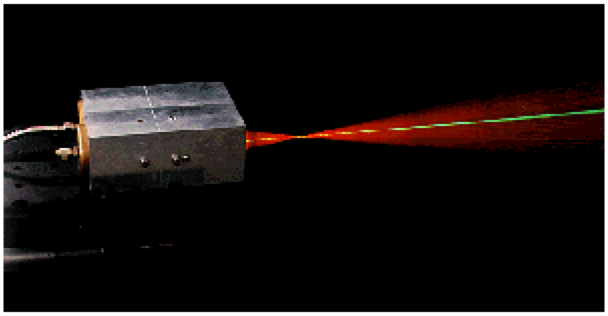
Diagnostics Adapted for Heat-Treating Furnace Environment

Diagnostics developed for the in situ monitoring of rocket combustion environments were adapted for use in heat-treating furnaces. Simultaneous, in situ monitoring of the carbon monoxide, carbon dioxide, methane, water, and hydrogen concentrations in the endothermic gas of a heat-treating furnace were demonstrated under a Space Act Agreement between the NASA Lewis Research Center, the Heat Treating Network, and Akron Steel Treating Company. This endothermic gas, or "endogas," is produced in a catalytic process, where natural gas is "cracked" in the presence of air. Variations in the composition of the natural gas supplied lead to variations in the composition of the endothermic gas. These variations could lead to an unacceptable quality of steel products that are hardened through the carborization process that uses this gas.

Conventional methods of monitoring the endogas include measuring the dew point of the gas and the oxygen concentration. From these data, the carbon monoxide content of the gas can be calculated. This carbon monoxide concentration creates the carbon potential needed for carburization. Several weak links are present in this approach. The oxygen monitor deteriorates over time, and the measurement might be inaccurate by 50 percent. Also, the chemistry equations, which are based on several assumptions, such as secondary species concentrations, provide only an approximate estimate of the carbon monoxide concentration .

To address these weaknesses, we investigated a new method based on ordinary Raman spectroscopy, in which the carbon monoxide concentration is measured directly and in situ. This method measures the laser light scattered from the molecules. Each species interacts with the light and scatters the light at a different frequency. Spectral monitoring of the scattered light intensity at each molecular frequency of interest provides the species concentrations. One advantage over the conventional method is that several species can be monitored simultaneously. A second advantage is that the measurement is direct; there is no need to make assumptions, to filter the gas, or to calibrate the instrument.

An instrument was designed consisting of a laser and a detection system within an enclosure, connected to an optical probe by fibers. For determining carbon monoxide concentration, the probe is mounted on the endothermic gas line, close to the generator. Optical fibers with a length of 150 ft have been used to transmit laser light from the instrument to the probe. There, the light is focused into the gas, and the scattered light is collected and transmitted back to the instrument where it is analyzed with a photomultiplier and lock-in amplifier. Laboratory tests have shown that with the current system the concentration of carbon monoxide, water, nitrogen, oxygen, and hydrogen in the air can be monitored with an accuracy of 1 percent. The concentration of carbon dioxide in the air can be monitored with an accuracy of 0.5 percent, and the concentration of methane with an accuracy of 0.2 percent.



Optical diagnostics probe in operation.

This instrument was taken to the Akron Steel Treating Plant, where field tests are in progress to verify the system capabilities. Planned developments are improving the accuracy, monitoring multiple locations, and reducing instrument size and cost.

Bibliography

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